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SPECIAL REPORT NO. 3
RESULTS OF AOC-1 ENDURANCE TEST

RELIABILITY, MAINTAINABILTY, AND AVAILABILITY OF THE MARINE TACTICAL DATA SYSTEM (MTDS)

December 1965

Prepared for
Bureau of Ships, Code 675
Department of the Navy
under Contract NObsr 91097

ARINC RESEARCH CORPORATION

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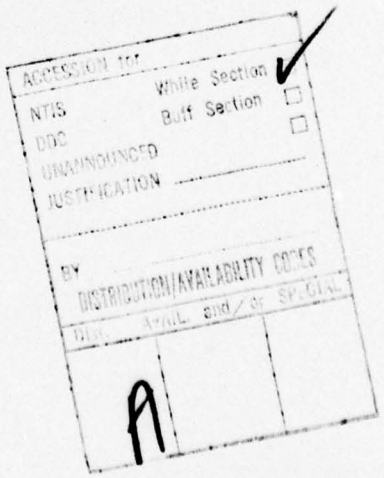

1. INTRODUCTION

During the reporting period, 5 through 30 November 1965, The Air Operations Central (AOC-1) was subjected to a 360-hour reliability/endurance test. The purpose of this test was to demonstrate that the following specification requirements for the basic system had been met:

(1) Mean-time-between-losses of a major function - 336 hours;

(2) Mean-time-between-losses of a tactical operational function - 50 hours; and

(3) System availability - 95% (based on loss of a tactical function).

2. ANALYSIS

Maintenance actions analyzed during the endurance test were classified according to the following types of failure:

(1) Type 1 Failure - Those maintenance actions which were the result of component (equipment) failure and caused the "loss of a major function."

(2) Type 2 Failure - Those maintenance actions which were the result of component (equipment) failure and caused the "loss or significant degradation of a tactical operational function."

(3) Type 3 Failure - Type 3 failures fall into two categories as follows:

(a) Those maintenance actions which were attributable to human error, defective workmanship, or preventive maintenance, regardless of effect on system function.

(b) Those maintenance actions which had insignificant or no effect on a tactical operational function.

(4) Type 4 Failure - Those maintenance actions which were attributable to failures of GFE equipment, regardless of effect on system function.

3. RESULTS

The results presented in Tables 1 through 17 are explained as follows:

(1) Type 2 failures for several system configurations are shown in Tables 1 and 2. Reliability calculations are the same in both tables. However, the Availability results in Table 1 are based on the best estimate of system MTTR derived from the calculations of Table 3. The Availability results in Table 2 are based on MTTR values derived from Type 2 failures only, as shown in Table 4.

(2) The number of Type 2, 3, and 4 failures which occurred during the test are identified in Table 5.

(3) Table 5 shows the number of maintenance actions by failure classification for the total system. Tables 6 through 15 show the number of maintenance actions which occurred in the individual huts.

(4) Table 16 describes the rationale used to classify Type 2 failures, indeterminate failures, and those that had been tentatively classed as Type 2 failures pending further information.

(5) No Type 1 failures were observed during the 360-hour test; thus, there is a 90% confidence that the mean-time-between-losses of a major function is in excess of 156 hours. Since no Type 1 failures occurred, Availability is estimated at 100%.

(6) Table 17 shows the observed AOC reliability on an individual hut basis.

4. CONCLUSIONS

Conclusions of the endurance tests conducted during this reporting period are presented as follows:

(1) The point estimate of mean-time-between-losses of a major function is in excess of 360 hours.

(2) The results shown in Table 1 present the best estimate of system behavior in MTBF, MTTR, and Availability in relation to the 50-hour mean-time-between-losses (or significant degradation) of a tactical operational function and its related 95% Availability requirements.

(3) The distribution within the system of the maintenance events observed during the 360-hour test differs considerably from the predicted maintenance allocation given in ARINC Research letter, ASP-65-268, dated 2 November 1965, in that the predicted allocation does not provide a valid means for

determining system MTTR. The value of system MTTR in Table 3 provides the best estimate considering the number and distribution of system maintenance actions.

5. RECOMMENDATIONS

Based on the results of this 360-hour test, it is recommended that:

(1) The system be considered to have met its specification requirement in terms of mean-time-between-losses of a major function (336 hours).

(2) The system be considered to have met its specification requirement in terms of mean-time-between-losses (or significant degradation) of a tactical operational function (50 hours).

(3) The system be considered to have met its specification requirement in terms of Availability (95%) relative to tactical operational functions.

Based on the fact that the observed distribution of maintenance actions differs markedly from the predicted distribution, it is further recommended that the results of Table 3 be used to determine system MTTR.

APPENDIX

Tables 1 through 17

TABLE 1

AOC-1
ENDURANCE TEST
SYSTEM RELIABILITY AND AVAILABILITY*

Configuration	Total Number of Failures	90% Confidence -that MTBF is greater than: (Hours)	Point Estimate MTBF (Hours)	MTTR* (Hours)	Availability
Huts I, II, III, VII, OP 101, Ancillary	3	54.0	120.0	0.7	.995
Huts I, II, III, VII, OP 102, Ancillary	4	45.0	90.0	0.7	.992
Huts I, II, III, VII, OP 103, Ancillary	3	54.0	120.0	0.7	.995
Huts I, II, III, VII, OP 100, Ancillary	3	54.0	120.0	0.7	.995
Huts I, II, III, VII, OP 105, Ancillary	2	67.5	180.0	0.7	.996
Huts I, II, III, VII, Average OP, Ancillary	3	54.0	120.0	0.7	.995

* Based on representative sample of significant repair actions during endurance test, reference Table 3.

TABLE 2

AOC-1
ENDURANCE TEST
SYSTEM RELIABILITY AND AVAILABILITY*

Configuration	Total Number of Failures	90% Confidence -that MTBF is greater than: (Hours)	Point Estimate MTBF (Hours)	MTTR* (Hours)	Availability
Huts I, II, III, VII, OP 101, Ancillary	3	54.0	120.0	1.18	.989
Huts I, II, III, VII, OP 102, Ancillary	4	45.0	90.0	1.52	.983
Huts I, II, III, VII, OP 103, Ancillary	3	54.0	120.0	1.21	.990
Huts I, II, III, VII, OP 104, Ancillary	3	54.0	120.0	1.13	.991
Huts I, II, III, VII, OP 105, Ancillary	2	67.5	180.0	1.65	.992
Huts I, II, III, VII, Average OP, Ancillary	3	54.0	120.0	1.34	.988

* Based on Type 2 failures only.

TABLE 3

AOC-1
ENDURANCE TEST
HUT MAINTAINABILITY
(Selected Representative Actions)*

Hut	Number of Maintenance Actions	Total Active Repair Time (Hours)	MTTR (Hours)
I	1	.5	.5
II	1	.4	.4
III	3	2.4	.8
VII	1	3.2	3.2
Ancillary	3	3.9	1.3
OP-101	28	11.8	.4
OP-102	20	11.7	.6
OP-103	21	11.7	.6
OP-104	12	4.8	.4
OP-105	28	17.5	.6
Average OP	22	11.5	.5
Average System	31	21.9	.7

* Selected representative actions include those failures observed during the test of a Type 2 nature and Type 3 failures whose repair characteristics were similar to those of Type 2 failures.

TABLE 4

AOC-1
ENDURANCE TEST
HUT MAINTAINABILITY

(Type 2 Failures)

Hut	Number of Maintenance Actions	Total Active Repair Time (Hours)	MTTR (Hours)
I	0	0	-
II	0	0	-
III	0	0	-
VII	1	3.17	3.17
Ancillary	0	0	-
OP-101	2	.38	.19
OP-102	3	2.93	.98
OP-103	2	.45	.23
OP-104	2	.28	.14
OP-105	1	.13	.13
Average OP	2	.84	.42
Average System	3	4.01	1.34

TABLE 5

AOC-1 ENDURANCE TEST
CLASSIFICATION OF MAINTENANCE ACTIONS
(Total System)

Cause \ Effect	Number of Maintenance Actions in Each Type of Failure			
	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)	0	11*	133**	29**
Peripheral (Q) or GFE Equipments #	1† (619 - Diesel Generator "G", PU-608)	7† (648-UPS-1 649-Microwave to Santa Ana 691-UHF, Channel -3 Radio 748-UHF Radio-1 640-TPS-37 675-GAGDT 681-PU-608)	2† (706-UHF Hut 791-UHF Hut)	1† (772 - Utility Phone)
Human (H) or Operator Errors	1**	4**	7**	1**
Design (D) Deficiency††	1	5	7	2
Workmanship (W)	0	3**	10**	1**
Preventive (P) Maintenance	0	0	0	0
Miscellaneous (M)	0	0	0	0
Indeterminate (U)	2	1	1	0

* Type 2 Failures
** Type 3 Failures
† Type 4 Failures
†† Determined by the Bureau of Ships
# GFE equipments in parenthesis are preceded by the last three digits of the Failure and Maintenance Report (FMR) number

Note: Letter designators in parenthesis are used to codify the failure classification described in Table 16.

TABLE 6

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Type I Central Computer Hut)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)			6	1
Peripheral (Q) or GFE Equipments		1		
Human (H) or Operator Errors	1	1		
Design (D) Deficiency	1	4	3	2
Workmanship (W)				
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)	2			

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 7

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Type II RIDP Hut)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)			2	1
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors				
Design (D) Deficiency				
Workmanship (W)				
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

Note: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 8

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Type III Radar-Mapper Hut)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)			2	
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors				
Design (D) Deficiency				
Workmanship (W)			1	1
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

Note: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 9

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Type VII Communications Hut)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		1		4
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors			1	
Design (D) Deficiency				
Workmanship (W)				
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 10
AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Operator Hut 101)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		2	32	4
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors			1	
Design (D) Deficiency		1	1	
Workmanship (W)		1	1	
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)		1	1	

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 11

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Operator Hut 102)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		3	18	5
Peripheral (Q) or GFE Equipments		1		1
Human (H) or Operator Errors		1		
Design (D) Deficiency			1	
Workmanship (W)		1		
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 12

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Operator Hut 103)

Cause \ Effect	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		2	27	8
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors		2	1	
Design (D) Deficiency			1	
Workmanship (W)			5	
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 13

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Operator Hut 104)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		2	18	1
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors			1	
Design (D) Deficiency				
Workmanship (W)				
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 14

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Operator Hut 105)

Cause \ Effect	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)		1	25	4
Peripheral (Q) or GFE Equipments				
Human (H) or Operator Errors			3	1
Design (D) Deficiency			1	
Workmanship (W)			3	
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 15

AOC-1 ENDURANCE TEST
MAINTENANCE CLASSIFICATIONS
(Ancillary Hut)

Effect / Cause	Total (T) Loss of a Major Function	Complete Loss (L) or Significant Degradation of Operating Function	Insignificant (I) Effect on a Tactical Operating Function	No (N) Direct Effect on a Tactical Operating Function
Component (C)			3	1
Peripheral (Q) or GFE Equipments		1		
Human (H) or Operator Errors				
Design (D) Deficiency				
Workmanship (W)		1		
Preventive (P) Maintenance				
Miscellaneous (M)				
Indeterminate (U)				

NOTE: Letter designators in parenthesis are used to codify the failure classifications described in Table 16.

TABLE 16

AOC-1
ENDURANCE TEST
(Hut Failures)

Hut	FMR	Date/Time Detected	Class-ification	Description (1) of Defect and Reason (2) for Classification
I	153580	11-6 1308	TU	(1) When live radar video was first applied to the system, many tentative tracks were received by the correlator; this caused saturation and a correlator error light. When the computer was cleared the fault was corrected and did not recur. (2) This fault was probably the result of a misadjustment of the noise threshold or a sudden burst of radar noise. The problem did not recur during the remainder of the endurance tests.
I	153693	11-12 1542	TU	(1) During flight tests, no height requests were processed by the Ancillary hut. The flight tests were continued without interruption to isolate this fault. On completion of the flight tests, the computer was cleared, and the fault did not recur.

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Class-ification	Description (1) of Defect and Reason (2) for Classification
				(2) The symptoms were similar to those produced by the failure of the operator in the Ancillary hut to respond to a height request. Under these conditions, clearing of the computer removed the fault indication. No electrical fault was found, and the problem did not recur at any time during the remainder of the endurance tests.
VII	153722	11-14 0530	LC-2	(1) During operational test, an error light was observed in the Intercenter Data Terminal (ICDT). This light indicated a failure of channel "C" which would cause the loss of digital data transmission for one of the four channels. If only one channel were assigned the only back-up capability would be voice communications. (2) This failure was in a Flip-Flop Card, 531102, and caused the loss of a Tactical function, Type 2.

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Classification	Description (1) of Defect and Reason (2) for Classification
OP Hut 101	153584	11-6 1550	IW-3 Reclassified from LC-2	(1) Because of a bad ICS module in Console 1-2, no visual indication was present which identified the station that originated the call. This defect made it necessary for the operator receiving the call to sequence through twenty switches to locate the station calling. (2) Initially, a light driver was considered to be the cause of failure, resulting in the removal and replacement of the module. Subsequently, it was determined that all the module's circuits were functioning properly, and the defect was caused by a broken lens "eyelet" that prevented the indicator light from being observed. This defect has now been traced to defective workmanship in the broken lens. Based upon these facts, the failure was reclassified as Type 3.
OP Hut 101	153607	11-7 2230	LC-2	(1) This failure was a console power shutdown with a thermal interlock indication. A NOR Inverter Card (Assembly 531103) was

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Classification	Description (1) of Defect and Reason (2) for Classification
				replaced in the Power Control Unit (Assembly 532370). (2) This failure was indicative of high-voltage arcing internal to the 19-inch cathode ray tube. (This failure caused the complete loss of this particular console.)
OP Hut 101	153682	11-12 0749	LU	(1) This failure was in the loss of Y deflection on the symbols caused by a defective minor deflection amplifier (Assembly 532353). This failure was observed after startup, following unscheduled shutdown of a PU-608 diesel generator that interrupted operation of Operator huts 101, 102, and 103. (2) This failure was believed to be associated with the unscheduled generator failure. Since normal console shutdown procedures could not be followed, the console damage was the most probable result.

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Classification	Description (1) of Defect and Reason (2) for Classification
OP Hut 101	153795	11-19 1756	LC-2	(1) Failure of a component of the Conducting Glass Amplifier Card (Assembly 531221) caused the loss of the Hooking function on the console.
OP Hut 102	153595	11-7 1040	LW-3	(1) An ICS module in the TTY Communications Console was determined to be defective. The operator reported that only two words could be heard when fading resulted; this caused complete loss of communications. This indicated a defective Squelch Control, and the module was replaced. This replaced module was forwarded to the Salt Lake City test unit for checkout and repair. The inspection at Salt Lake City showed no evidence of a defect in the module. (2) Return of the unit to Van Nuys for engineering evaluation revealed that during manufacture an 18KΩ resistor had been installed which should have been 1.8KΩ. The prescribed test procedures that involved

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Classification	Description (1) of Defect and Reason (2) for Classification
				application of a constant tone signal to test the squelch circuit would not detect a defect of this nature. On the basis of the above facts, this failure was reclassified a workmanship error, Type 3.
OP Hut 102	153603	11-7 1620	LC-2	(1) This failure was a console power shutdown with a thermal interlock indication. The NOR Inverter Card (Assembly 531103) in the Power Control Unit (Assembly 532370) and the Sweep Pedestal Generator Card in the right-hand card rack of the Console Indicator were replaced. (2) These card failures are characteristic of internal CRI arcing of the type which caused the loss of Console 2-3.

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Class-ification	Description (1) of Defect and Reason (2) for Classification
OP Hut 102	153677	11-12 0115	LC-2	(1) Failure of a component of the Conducting Glass Amplifier Card (Assembly 531221) caused the loss of the Hooking function on the Console.
OP Hut 102	153694	11-12 1615	LC-2	(1) Failure of a Comparator Card (Assembly 531207) caused the loss of the Hooking function on one Console. (2) The initial card stock replacement was defective necessitating the reordering of an additional replacement. Thus, two FMR's were grouped into a single maintenance action in this failure (FMR 153719).
OP Hut 103	153769	11-17 1618	LC-2	(1) Failure of a Shift Register Card (Assembly 531110) caused a loss of the Pencil Hooking function except when the target was

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Class-ification	Description (1) of Defect and Reason (2) for Classification
				on the 0° to 180° azimuth line. This severe degradation of the Hooking function occurred in Console 3-2 and constituted a failure of the Hooking function.
OP Hut 103	153773	11-17 1950	LC-2	(1) Console 3-2 experienced a power supply shutdown when the 30-volt power supply (Assembly 532134) failed; the current indicator lights were illuminated on the power control assembly. This failure resulted in the total loss of the console.
OP Hut 104	153617	11-8 0645	LC-2	(1) Console Power would not turn on because of a defective power supply (Assembly 532134). This failure caused the loss of Console 4-1.
OP Hut 104	153687	11-12 1135	LC-2	(1) This failure involved a console power shutdown with thermal interlock indications. NOR Inverter Card (Assembly 531103) was replaced in the Power Control (Assembly 532370). (2) This failure is indicative of H. V.

TABLE 16 (continued)

Hut	FMR	Date/Time Detected	Class-ification	Description (1) of Defect and Reason (2) for Classification
				arcing in the 19" CRT. A total loss of Console 4-1 was experienced.
OP Hut 105	153652	11-9-65 2157	LC-2	(1) The failure of a Shift Register Card (Part Number 531110) caused the loss of the Pencil Hooking function on Console 5-3.

TABLE 17

AOC-1
ENDURANCE TEST
HUT RELIABILITY

(Type 2 Failures)

Hut	Number of Failures	90% Confidence -that MTBF is greater than: (Hours)	Point * Estimate MTBF (Hours)	Point * Estimate Failure Rate (per 1000 Hours)
I	0	156.0	—	0
II	0	156.0	—	0
III	0	156.0	—	0
VII	1	92.5	360.0	0.278
Ancillary	0	156.0	—	0
OP-101	2	67.5	180.0	0.555
OP-102	3	54.0	120.0	0.835
OP-103	2	67.5	130.0	0.555
OP-104	2	67.5	130.0	0.555
OP-105	1	92.5	360.0	0.278
Average OP	2	67.5	180.0	0.555

* Based on 360-hour test.